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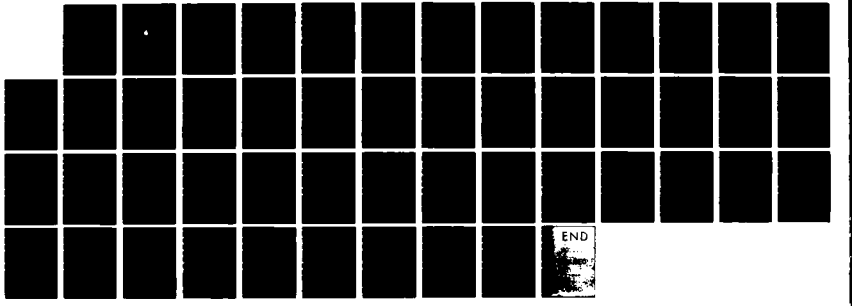

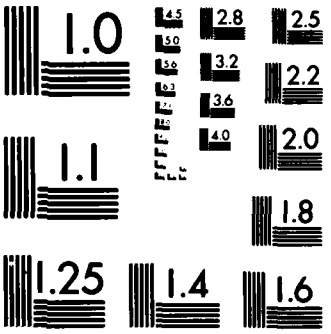

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WHOI-84-39

Woods Hole Oceanographic Institution

The Long Term Upper Ocean Study (LOTUS)

Cruise Summary and Hydrographic Data Report

OCEANUS 154, May 1984

by

Ellyn T. Montgomery, Nancy J. Pennington
and Melbourne G. Briscoe

October 1984

Technical Report

Funding was provided by the Office of Naval Research under Contract N00014-84-C-0134, NR 083-400.

Approved for public release: distribution unlimited.

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Approved for Distribution:

N. P. Fofonoff

Nick P. Fofonoff, Chairman
Department of Physical Oceanography

ABSTRACT

OCEANUS cruise 154 (16-23 May 1984) was the final cruise in the two year field program of the Long Term Upper Ocean Study (LOTUS). The work occurred primarily in the LOTUS area (34°N, 70°W), where the entire moored array was recovered. The moorings were the following: the LOTUS-6 surface mooring (No. 792), a subsurface mooring (No. 788), two intermediate moorings (Nos. 789, 790), and a C. S. Draper Labs profiling current meter (PCM1H) mooring.

Also on OCEANUS 154, a mooring was deployed for the U. S. Geological Survey at approximately 40°10'N, 69°58'W. On the return trip, an engineering test mooring was recovered at approximately 39°11'N, 70°01'W, some elements removed for testing, and then redeployed in the same location.

This report presents the hydrographic data collected on OCEANUS 154, as well as providing details of the work that was accomplished.

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ACKNOWLEDGEMENTS

The LOTUS moorings set and recovered during OCEANUS cruise 154 were designed, prepared and handled at sea by the WHOI Buoy Group, composed of personnel from the Physical Oceanography Department and the Ocean Structures and Moorings Section of the Ocean Engineering Department.

We are grateful for the skill of Captain Paul Howland and the personnel of the R/V OCEANUS. We thank Richard Trask for his help on this report.

This work was supported by the Office of Naval Research under Contract N00014-84-C-0134, NR 083-400.

PART I

Introduction

Cruise number 154 of the R/V OCEANUS was the last cruise of the Long Term Upper Ocean Study (LOTUS). The purposes of the cruise were to recover all the moorings in the LOTUS area (34°N, 70°W) and to perform associated hydrographic work. The recovery of the moored array produced the second year of current meter and thermistor chain data from the LOTUS site, culminating the two year field program (Briscoe and Weller, 1984).

Figure 1 shows the LOTUS area (33°-35°N, 69°-71°W) relative to the Gulf Stream, the east coast of the United States and Bermuda. The site is in the mid-ocean away from the direct influences of topography and the Gulf Stream, in the path of hurricanes and Gulf Stream rings, and at the edge of the region of eighteen degree water formation and high eddy kinetic energy.

Two design trials, LOTUS-1 and 2, to test surface moorings, were conducted prior to the data acquisition phase of the LOTUS project (Trask, Briscoe and Pennington, 1982). Four science deployments followed, making up the bulk of the LOTUS experiment. The first science deployment occurred in May 1982, and was designated LOTUS-3. A surface mooring, a near-surface mooring, and two subsurface moorings were deployed at that time. Details of that deployment can be found in the report by Trask and Briscoe (1983a). The LOTUS surface moorings were replaced every six months, whereas the near-surface and subsurface moorings were replaced annually. Consequently, in October-November 1982, the surface mooring deployed in May 1982 was replaced with a nearly identical surface mooring, designated LOTUS-4 (Trask and Briscoe, 1983b). Approximately six months later in April 1983, the entire moored array was replaced (Trask and Briscoe, 1983c). During October-November 1983, the surface mooring designated LOTUS-5 (deployed in April 1983) was recovered, but the one to replace it was damaged and could not be deployed. In January 1984 the final science deployment occurred, as a new surface mooring, designated LOTUS-6, was successfully deployed. The events of October-November 1983 and January 1984 are detailed in the report by Montgomery, Pennington and Briscoe (1984). In May 1984 on OCEANUS 154, the final cruise of the LOTUS experiment, all the moorings in the LOTUS area were recovered.

This data report summarizes the work accomplished on OCEANUS 154, and the hydrographic data collected. The major cruise events, including mooring work, are presented in Part I. The data from the CTD stations completed, and the XBT sections made during the cruise are shown in Part II. With the recovery of the moored array during OCEANUS 154, the current meter report for year two of LOTUS will become available. Table I gives the nominal contents and publication dates of the entire LOTUS report series.

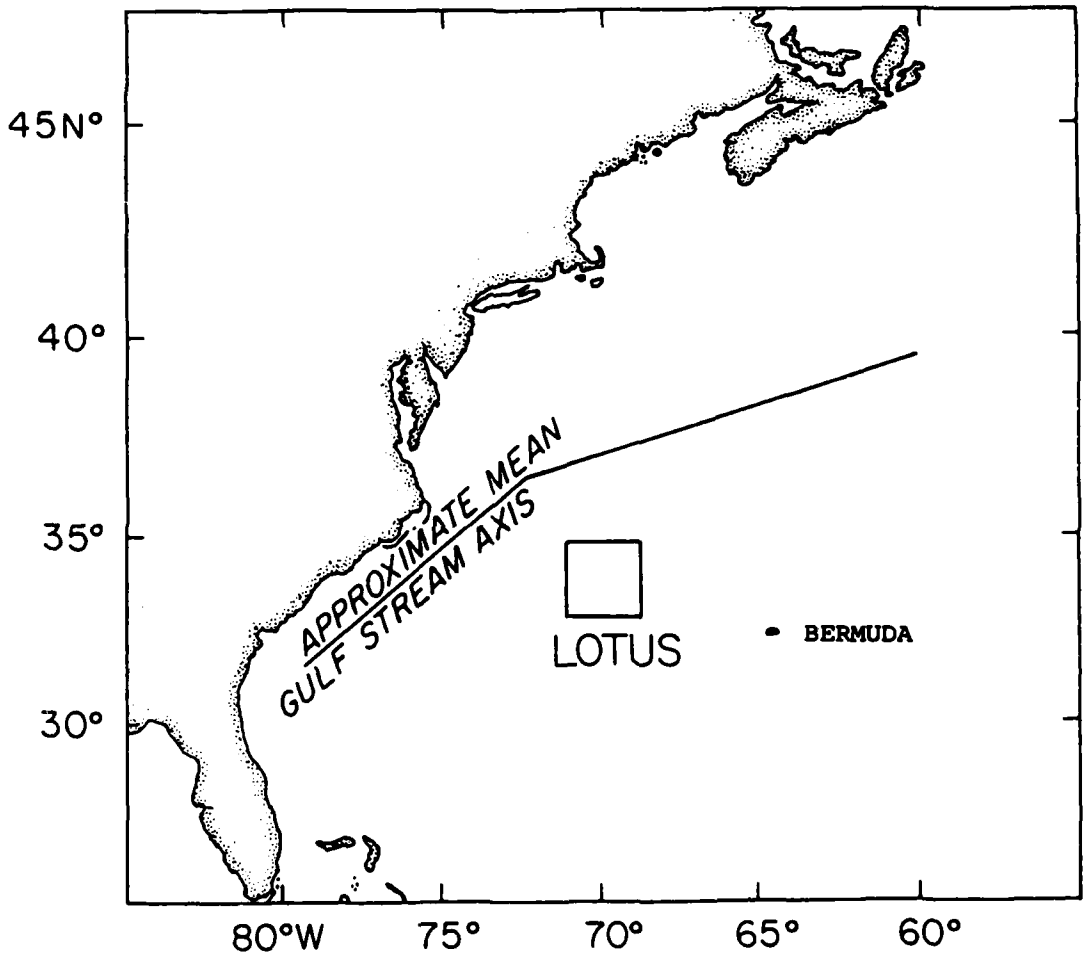

Figure 1. The location of the Long Term Upper-Ocean Study (LOTUS) area.

Table 1. LOTUS-related WHOI Technical Reports.

PRESENTLY AVAILABLE REPORTS

Title	WHOI No.	Date
Long Term Upper Ocean Study (LOTUS) A Summary of the Historical Data and Engineering Test Data.	82-53	Dec 82
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 119 - May 1982.	83-7	Feb 83
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 129, Oct 1982.	83-29	Aug 83
Long Term Upper Ocean Study (LOTUS) at 34°N, 70°W Meteorological Sensors, Data, and Heat Fluxes for May-October 1982 (LOTUS-3 and LOTUS-4).	83-32	Sept 83
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, ENDEAVOR 97, April 1983.	83-33	Oct 83
The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 141, November 1983, and OCEANUS 145, January 1984.	84-26	June 84
A Compilation of Moored Current Meter and Wind Recorder Data Volume XXXV, Long-Term Upper Ocean Study (LOTUS) (Moorings 764, 765, 766, 767, 770) May 1982-April 1983.	84-36	Aug 84
* The Long Term Upper Ocean Study (LOTUS) Cruise Summary and Hydrographic Data Report, OCEANUS 154, May 1984.	84-39	Sept 84

PLANNED FUTURE REPORTS

Subject	Expected Availability
Meteorological data report, LOTUS-5 and LOTUS-6.	Fall 84
Current meter data report, LOTUS-5 and 6.	Fall 84
A summary of the LOTUS experiment.	Winter 85

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* This report.

Navigation

During OCEANUS 154 two systems of navigation, both based on LORAN C, were utilized. Positions from the more conventional system which has been used during previous LOTUS cruises are based on the geographical calculation performed by the Northstar 7000 LORAN-C unit. The second system uses only the time delays from the Northstar 7000 unit. A position is determined by an independent geographical calculation which makes use of a knowledge of the additional secondary phase factors for the LOTUS area and the transit region. The calculation is performed by a Hewlett-Packard 85 desk top computer, thus the second system has been termed NAV85. A small program error was found in the system on OCEANUS 141, but was corrected in time for use on OCEANUS 145. The error gave NAV85 position offsets if the ship was steaming full-ahead. The system functioned properly on the latter cruise and on OCEANUS 154, but no detailed study has been made of the accuracy of the system. Therefore the NAV85 continues to be in the development stage. All positions shown in this report are based on the geographical calculation performed by the Northstar 7000 LORAN-C unit.

The Northstar algorithm provides a geographical position that is southeast of the true (satellite based) position. From numerous simultaneous position fixes in the LOTUS area we have determined an average offset of the LORAN-based calculation. Table 2 shows the offsets and standard deviations for the Northstar 7000. Positions listed in Tables and Figures in this report are all the Northstar 7000 positions; to convert to absolute geographical positions the offsets shown for the Northstar 7000 in Table 2 should be added.

Table 2. Offsets (and standard deviations) <u>from</u> LORAN position <u>to</u> geographical position, based on simultaneous LORAN and satellite position fixes (GEOG = LORAN + OFFSET).

	OFFSET (S.D.)		OFFSET (S.D.)	
UNIT	North	West	Range [km]*	Bearing
Northstar 7000	1.07' (.15)	1.24' (.16)	2.76' (.32)	316° (4)

* 1 km = .54 nautical miles.

was based on an Olympus OM-2 camera body, but had an 8 mm f/2.8 fisheye lens and a 250 shot back, and was secured in a watertight case. The radar camera was triggered by hand, but the mast camera was triggered remotely with a button in the main lab. Both camera systems were designed to see streaks and patterns on the surface, especially lines of Sargassum weed and internal wave slicks.

Seven CTD stations were attempted in the LOTUS area on OCEANUS 154, but due to a problem with the shorting plug on the CTD, the data from three of the casts were lost. An XBT section was completed along 70°W on the southbound trip. As well, three detailed XBT sections were done in the LOTUS area: one along 34°N, from 69°30'W to 70°30'W; one along 70°W, from 33°30'N to 34°30'N; and the last in a northwesterly direction from the east point of the cross to the north point. The details of the CTD and XBT work on OCEANUS 154 are presented in section II: Hydrographic Data. A chronological log of OCEANUS 154 and a plot of the cruise track are shown in the appendix.

Cruise Summary

OCEANUS 154

May 1984

Cruise number 154 of the R/V OCEANUS was the final cruise of the LOTUS experiment (January 1980-December 1985). The ship left Woods Hole on 16 May 1984 bound for the LOTUS area (34°N, 70°W), and returned to Woods Hole after eight days, on 23 May 1984.

During the cruise, all the moorings used in the final deployment of the LOTUS experiment were recovered: these included; the surface mooring (792); the subsurface mooring (788); the south and east intermediate moorings (790 and 789, respectively); and the C. S. Draper Lab-M.I.T. Profiling Current Meter (PCM1H). Figure 2 is a chart showing where the moorings were located and this information, as well as the setting dates, is listed in Table 3. Diagrams of the moorings recovered on OCEANUS 154 are shown in Figure 3.

Upon arrival at the LOTUS surface mooring, the Datawell internally recording Waverider buoy was observed to be no longer attached to the discus buoy, and was nowhere in sight. After the surface mooring was recovered, it was apparent that the Waverider's motion had caused the shackle pin on the tether line to wear through the welded eye where it was attached to the discus buoy. Consequently, the Waverider was not recovered.

Two moorings were deployed outside the LOTUS area on OCEANUS 154. The first was set for B. Butman (U.S.G.S.) at 40°10.88'N, 69°58.31'W. The second was the engineering test mooring (mooring number 791) at Site D. It was recovered at 39°11.80'N, 70°01.048'W, and then certain components of the mooring line were removed for testing at WHOI. The mooring (number 808) was subsequently redeployed at 39°12.29'N, 70°01.68'W. Finally, on the way back to Woods Hole, the light on a buoy south of Block Island was replaced for P. Biscaye (Lamont-Doherty).

Non-mooring work on OCEANUS 154 consisted of test trials of two camera systems, one used to photograph the ship's radar screen and the other to photograph the entire ship and surrounding sea surface. The system used on the radar consisted of an Olympus OM-1 camera body with a 24 mm f/2.8 lens and automatic winder, mounted on a shock absorbing tripod over the radar, covered with a light opaque hood. The system suspended from the catwalk on the mast

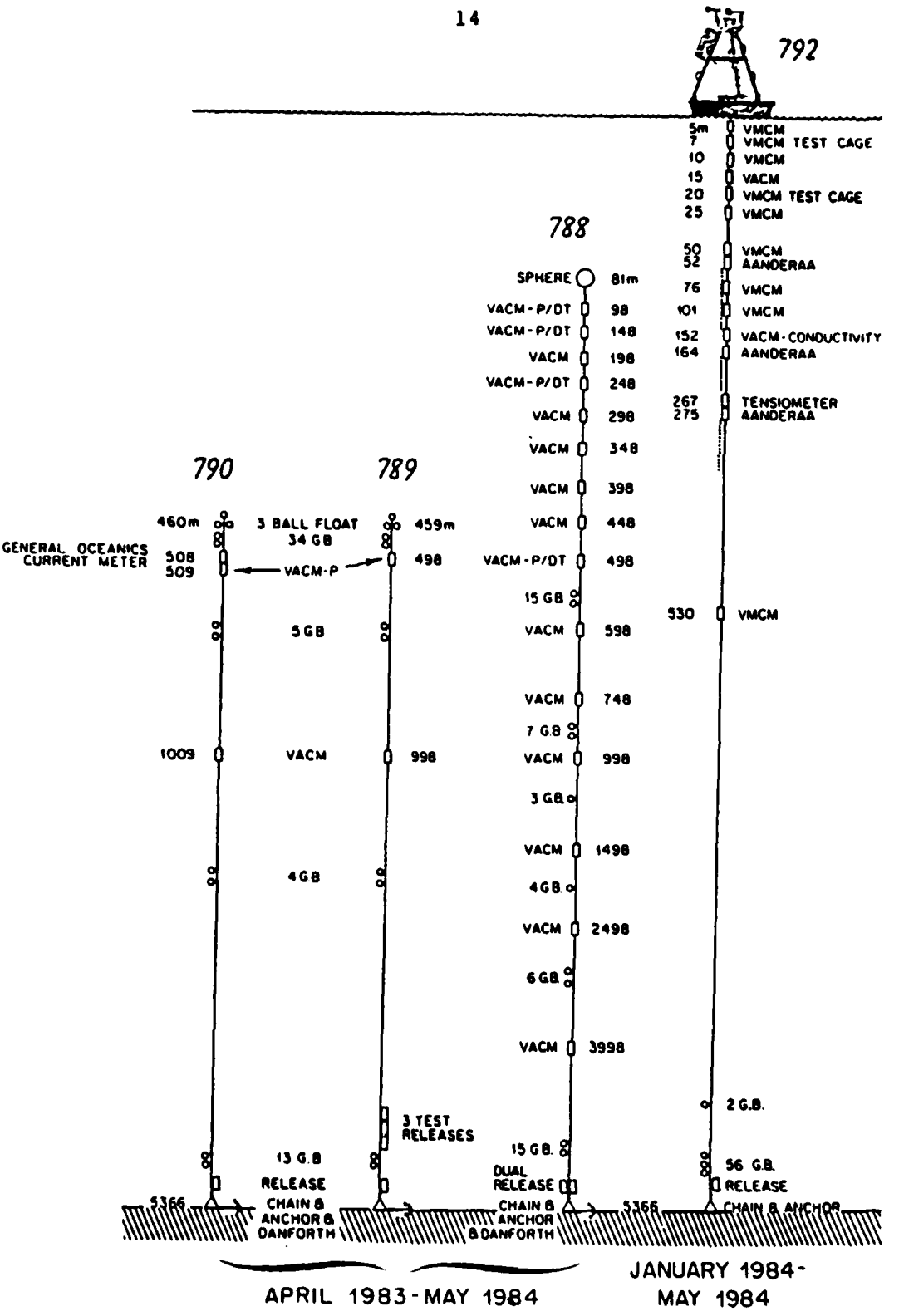

Figure 3. Diagrams of the four LOTUS moorings in the LOTUS area, recovered on OCEANUS 154.

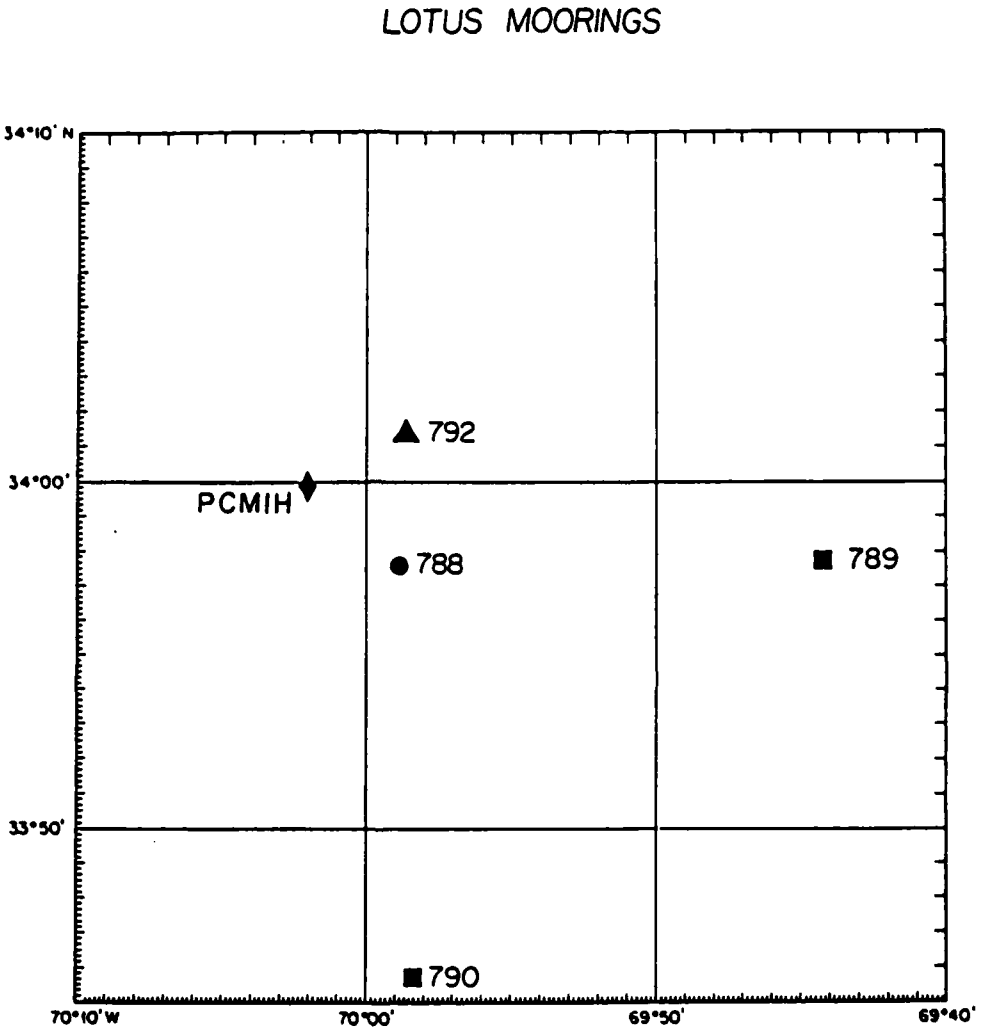

Figure 2. A chart of a section of the LOTUS area showing the location of the LOTUS-6 surface mooring (▲), near-surface mooring (●), subsurface moorings (■) and PCM1H (◆) recovered on OCEANUS cruise 154.

Table 3. A summary of the positions of the moorings (in the LOTUS area) recovered on OCEANUS 154.

Mooring ID	Date/Time Set	LORAN-C Anchor Position	
792 LOTUS-6 Surface Mooring	20 January, 1984/2200Z	34°01.29'N	69°58.63'W
788 LOTUS-5 Near-surface	13 April 83/0447Z	33°57.56'N	69°58.91'W
789 LOTUS-5 East Intermediate	14 April 83/2041Z	33°57.41'N	69°44.34'W
790 LOTUS-5 South Intermediate	15 April 83/1740Z	33°45.55'N	69°58.90'W
PCM1H MIT-Draper Labs Profiling Current Meter	3 November 83/0113Z	33°59.95'N	70°02.37'W

Notes: (1) PCM1H is a new designation for PCM-Zeta, as given in Montgomery et al. (1984).

(2) These anchor positions are updated from Montgomery et al. (1984), based on a new positioning algorithm.

PART II

Hydrographic Data

The following is a brief discussion of calibration and preliminary processing procedures used in our CTD work.

Data Presentation

The CTD/IR data are presented in two forms, tabular listings and graphical profiles. The profiles are reproductions of the original computer plots. Included here are profiles of potential temperature, salinity, Brunt Väisälä frequency, and potential density referenced to the surface (Figures 5-9). Full depth profiles as well as profiles of the upper 750 meters are presented. In addition a potential temperature-salinity diagram is presented for each station. The listings of data (Tables 5-9) include the above parameters plus sigma-t, potential temperature gradient, dynamic height, and sound speed, all at standard pressures as well as at the design depths of the instrumentation on the moorings.

The heading of the tabular listing includes the ship name (OC = OCEANUS) and cruise number, CTD number, year, year day, time, the latitude and longitude (LORAN-7000 position) of the CTD station when it started and the water depth at that station. Abbreviations used in the listings include PRESS for pressure, TEMP for temperature, SALIN for salinity, POTEMP for potential temperature, POTGRD for potential temperature gradient, POTDEN for potential density, BR-V for Brunt Väisälä frequency, SSPEED for sound speed and DYNHGT for dynamic height.

Summary of Calibration and Data Processing Procedures

The CTD/IR routinely undergoes pre-cruise laboratory calibrations at WHOI. The laboratory calibration of the temperature and pressure sensors is relied on totally for adjusting the calibration coefficients of those sensors. The conductivity sensor is calibrated using water samples collected at the bottom of each cast. Based on a comparison of the water sample salinities and the CTD/IR conductivity readings, a conductivity cell factor is computed for

each station. The cell factor is the scaling factor by which the measured conductivity must be multiplied to obtain the "true" conductivity. The conductivity values of the entire cast are then multiplied by the appropriate cell factor to obtain the "true" conductivities.

The preliminary CTD/IR data processing is accomplished with a SEA DATA 12A cassette reader and Asynchronous Reader Interface in conjunction with a Hewlett Packard (HP) 85 desk top computer and HP 5.25 inch flexible disc drive, printer and 7225B plotter. The preliminary processing takes the raw down cast data from cassette and applies the appropriate calibration coefficients, edits wild points, applies a pressure and conductivity sensor time lag correction, pressure averages the data (2 dbar pressure range) and stores the data on flexible disc.

All salinity computations are based on the 1978 Practical Salinity Scale (Lewis and Perkin, 1981) as recommended by the Joint Panel on Oceanographic Tables and Standards. Further processing incorporates the new equation of state for sea water (Millero, et al., 1980) for computing density and its related parameters such as specific volume and specific volume anomaly. Potential temperature at a reference pressure is computed using a fourth order Runge Kutta integration algorithm (Fofonoff, 1977) which uses the Bryden (1973) polynomial for adiabatic lapse rate. Sound speed calculations are based on the algorithms of Chen and Millero (1977). These algorithms are the basis of further computations which yield quantities of sigma-t, sigma-theta, dynamic height, potential temperature gradients and Brunt-Väisälä frequency. The Brunt-Väisälä frequency calculation incorporates a sliding least squares fit to the potential density data over user specified smoothing windows. Four windows were chosen for this calculation. A smoothing interval of 10 dbars was used between 0 and 150 dbars, a 30 dbar interval between 150 and 1500 dbars, 62 dbar interval between 1500 and 3500 dbars and a 90 dbar smoothing interval between 3500 dbars and the bottom.

A. CTD Data:

Seven CTD stations were made in the LOTUS area during OCEANUS 154. The measurements were made by a Neil Brown Instrument Systems internal recording conductivity-temperature-depth profiler (CTD/IR); mechanical and operational details of the LOTUS CTD/IR are found in the report by Trask (1981).

A fault in the switched shorting plug that stops the CTD/IR's internal recorder caused the first tape to be only one long file with CTD 1 and CTD 2 on it, along with a lot of bad data recorded while the CTD/IR was on deck and presumed to be stopped. CTD casts 3, 4 and 5 should also have been on tape one, but since the recorder did not turn off when it should have, the tape ran out before it was expected to and CTD casts 3, 4 and 5 were lost. Stations 6 and 7 were recorded on tape two, and the problem with stopping the tape was circumvented by using a fixed shorting plug, rather than relying on the switched plug.

Station 1 was performed near the position of the east intermediate mooring, and was terminated at 3600 m because the pinger on the CTD/IR indicated that the Nansen bottles and CTD/IR had tripped accidentally at this depth. Station 2 was completed northwest of the PCM1H and subsurface mooring and went to a depth of 5300 m. Station 6 was a short cast to 500 m, completed near the LOTUS-6 surface mooring, immediately prior to the mooring recovery. Station 7 was done near the position of the south intermediate mooring. Figure 4 shows the locations of the four CTD/IR stations for which there is good data.

Table 4: A summary of the CTD/IR work conducted on OCEANUS cruise 154.

CTD Station	Date (year day)	Start Time (UTC)	Deployed Position Lat. (N)	Long. (W)	Pressure Range (dbar)
1	20 May 84 (140)	0317	33°57.98'	69°45.10'	0-3691 m
2	20 May 84 (140)	0746	34°06.07'	70°08.01'	0-5362 m
6	21 May 84 (141)	1343	34°02.68'	69°58.94'	0-500 m
7	21 May 84 (141)	2337	33°45.57'	69°59.19'	0-5242 m

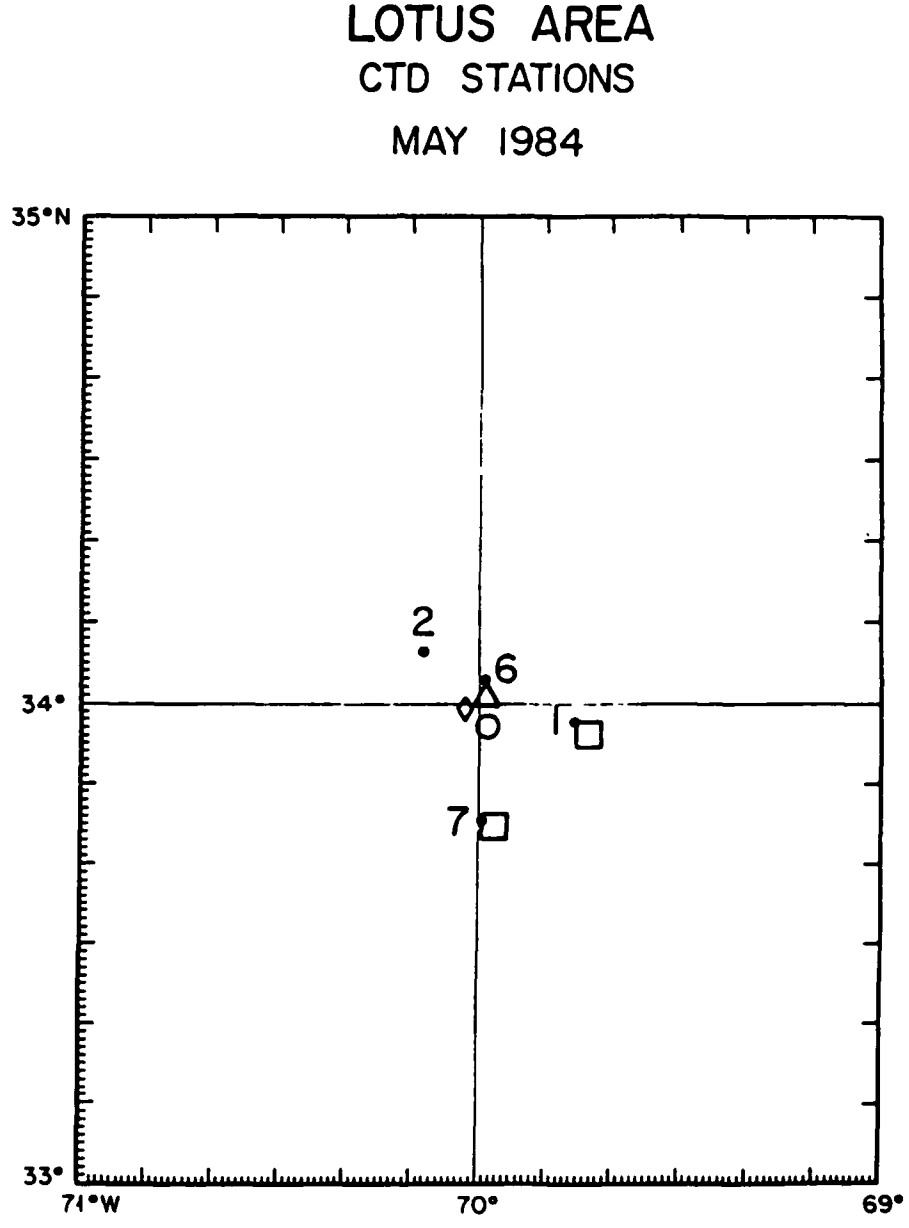

Figure 4. Chart of the LOTUS area showing the locations of the CTD/IR stations (●) made during OCEANUS 154 and their proximity to the LOTUS-6 surface mooring (△), near-surface mooring (○), subsurface moorings (□), and PCM1H (◇).

Table 5: Listing of CTD data and derived quantities for station 1.

OC154	CTD 001		1984 140 0317Z		33 58.3N	69 45.71W		corrD:	5363m
PRESS	TEMP	SALIN	POTEMP	POTGRD	SIGMA-t	POTDEN	BR-V	DYNHGT	SSPEED
dbar	°C	psu	°C	m°C/db	kg/m**3	kg/m**3	cph	dyn m	m/s
2.	22.061	36.453	22.061	0.00	25.323	25.315	0.00	0.0000	1528.6
6.	22.073	36.449	22.072	-1.35	25.317	25.309	-.70	.0098	1528.7
10.	22.074	36.449	22.072	-1.85	25.316	25.309	-.70	.0202	1528.8
16.	22.078	36.449	22.075	-.32	25.315	25.308	.38	.0364	1528.9
20.	22.072	36.449	22.069	3.34	25.316	25.310	.68	.0482	1529.0
26.	22.076	36.449	22.071	.20	25.315	25.309	.62	.0632	1529.1
30.	22.073	36.448	22.067	1.02	25.316	25.310	1.52	.0739	1529.1
36.	21.951	36.416	21.944	60.52	25.326	25.320	13.03	.0900	1528.9
50.	20.535	36.512	20.526	17.50	25.789	25.785	4.78	.1221	1525.4
66.	20.230	36.519	20.218	18.76	25.876	25.873	3.65	.1578	1524.9
76.	20.089	36.514	20.075	20.96	25.910	25.907	3.49	.1794	1524.7
100.	19.736	36.515	19.718	6.09	26.004	26.002	3.52	.2296	1524.1
126.	19.238	36.487	19.216	32.28	26.113	26.112	3.61	.2816	1523.1
150.	18.987	36.493	18.961	5.55	26.182	26.183	3.08	.3274	1522.8
200.	18.609	36.496	18.574	4.44	26.281	26.284	2.07	.4190	1522.6
250.	18.403	36.495	18.360	2.04	26.333	26.338	1.89	.5099	1522.8
300.	18.211	36.505	18.159	3.28	26.389	26.395	1.83	.5972	1523.1
350.	17.953	36.491	17.892	1.50	26.443	26.451	1.50	.6841	1523.2
400.	17.767	36.478	17.698	4.67	26.478	26.489	1.26	.7685	1523.4
450.	17.492	36.446	17.416	5.70	26.521	26.534	1.80	.8529	1523.4
500.	17.149	36.393	17.065	7.26	26.564	26.578	1.62	.9356	1523.2
550.	16.803	36.334	16.711	11.38	26.602	26.617	1.82	1.0173	1522.9
600.	16.129	36.208	16.032	17.00	26.664	26.680	2.54	1.0966	1521.5
650.	15.175	36.045	15.074	14.39	26.755	26.771	2.31	1.1732	1519.2
700.	14.311	35.903	14.206	-.69	26.836	26.851	1.86	1.2456	1517.1
750.	13.233	35.739	13.126	10.16	26.935	26.950	2.86	1.3148	1514.2
800.	12.023	35.556	11.916	26.09	27.035	27.047	2.94	1.3795	1510.8
900.	9.733	35.279	9.626	44.64	27.234	27.243	2.84	1.4920	1504.1
1000.	7.623	35.114	7.519	11.56	27.439	27.444	2.87	1.5853	1497.7
1100.	6.243	35.069	6.139	10.78	27.597	27.599	2.30	1.6591	1493.9
1200.	5.528	35.070	5.421	13.28	27.689	27.690	1.47	1.7198	1492.7
1300.	5.122	35.062	5.008	.33	27.731	27.733	1.09	1.7746	1492.8
1400.	4.805	35.040	4.685	2.67	27.751	27.753	.95	1.8267	1493.1
1500.	4.539	35.017	4.412	3.03	27.762	27.765	.78	1.8775	1493.6
1600.	4.345	35.003	4.212	3.52	27.773	27.775	.66	1.9275	1494.5
1800.	4.067	34.990	3.918	1.43	27.793	27.796	.68	2.0262	1496.7
2000.	3.890	34.992	3.724	.80	27.813	27.818	.79	2.1224	1499.3
2200.	3.702	34.989	3.520	1.22	27.829	27.836	.66	2.2175	1501.9
2400.	3.526	34.983	3.326	.49	27.842	27.850	.64	2.3111	1504.5
2500.	3.414	34.975	3.207	2.76	27.848	27.856	.64	2.3575	1505.7
2600.	3.330	34.970	3.114	2.13	27.852	27.860	.64	2.4036	1507.0
2800.	3.129	34.957	2.896	1.30	27.860	27.870	.68	2.4948	1509.5
3000.	2.961	34.946	2.711	.99	27.867	27.878	.58	2.5854	1512.2
3200.	2.811	34.936	2.543	.90	27.873	27.885	.56	2.6747	1515.0
3400.	2.658	34.927	2.373	.50	27.879	27.892	.57	2.7629	1517.7
3600.	2.548	34.921	2.244	1.51	27.884	27.898	.49	2.8505	1520.7

Table 6: Listing of CTD data and derived quantities for station 2.

OC154	CTD 002		1984 140 0746Z		34 06.19N	70 08.53W		corrD: 5370m	
PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	DYNHGT dyn m	SSPEED m/s
0.	0.000	0.000	-.000	0.00	-.093	-.147	0.00	0.0000	1402.4
6.	20.718	36.513	20.717	-3437.70	25.740	25.734	96.37	.0897	1525.2
10.	20.717	36.512	20.716	.82	25.740	25.733	-.52	.0985	1525.3
16.	20.720	36.512	20.717	-.11	25.739	25.732	-.48	.1116	1525.4
20.	20.721	36.512	20.718	.41	25.738	25.732	-.18	.1209	1525.5
26.	20.720	36.511	20.716	.98	25.738	25.732	-.47	.1346	1525.5
30.	20.725	36.511	20.719	-.05	25.737	25.732	-.44	.1441	1525.6
36.	20.725	36.512	20.718	.18	25.738	25.732	-.65	.1568	1525.7
50.	20.728	36.511	20.719	.02	25.736	25.731	.51	.1891	1526.0
66.	20.730	36.511	20.718	.01	25.735	25.732	.62	.2259	1526.2
76.	20.696	36.509	20.682	10.70	25.743	25.740	4.51	.2489	1526.3
100.	19.422	36.490	19.404	21.74	26.068	26.066	3.78	.2987	1523.2
126.	19.117	36.485	19.095	18.91	26.143	26.143	3.26	.3498	1522.8
150.	18.898	36.500	18.871	2.17	26.211	26.211	2.99	.3948	1522.6
200.	18.598	36.497	18.562	7.85	26.285	26.288	2.37	.4861	1522.5
250.	18.350	36.524	18.306	2.60	26.368	26.373	1.97	.5754	1522.7
300.	18.050	36.500	17.998	2.82	26.425	26.432	1.88	.6613	1522.6
350.	17.837	36.494	17.776	6.91	26.473	26.482	1.72	.7462	1522.8
400.	17.536	36.444	17.468	10.60	26.509	26.520	1.35	.8295	1522.7
450.	17.304	36.417	17.228	5.29	26.545	26.557	1.58	.9126	1522.8
500.	17.020	36.375	16.936	4.32	26.582	26.595	1.41	.9942	1522.8
550.	16.502	36.274	16.411	4.32	26.627	26.642	2.09	1.0744	1521.9
600.	15.584	36.106	15.489	29.97	26.711	26.725	2.53	1.1525	1519.7
650.	14.675	35.954	14.577	19.02	26.796	26.811	2.50	1.2266	1517.5
700.	13.808	35.819	13.705	12.35	26.878	26.892	2.34	1.2971	1515.4
750.	12.727	35.657	12.623	19.59	26.975	26.988	2.97	1.3632	1512.5
800.	11.429	35.473	11.325	43.16	27.083	27.093	3.27	1.4246	1508.6
900.	9.210	35.236	9.106	15.93	27.288	27.295	2.16	1.5301	1502.1
1000.	7.525	35.123	7.422	9.56	27.461	27.465	2.68	1.6191	1497.3
1100.	6.357	35.092	6.252	14.25	27.599	27.602	2.32	1.6910	1494.4
1200.	5.589	35.067	5.481	9.37	27.679	27.680	1.42	1.7518	1493.0
1300.	5.090	35.052	4.977	7.74	27.727	27.728	1.13	1.8070	1492.6
1400.	4.718	35.023	4.600	1.16	27.747	27.749	.75	1.8591	1492.7
1500.	4.481	35.005	4.355	1.48	27.759	27.761	.83	1.9102	1493.4
1600.	4.350	35.006	4.216	2.28	27.774	27.777	.65	1.9602	1494.5
1800.	4.132	34.999	3.982	2.03	27.793	27.797	.61	2.0590	1497.0
2000.	3.944	34.998	3.778	.47	27.812	27.817	.69	2.1566	1499.5
2200.	3.734	34.991	3.551	1.75	27.828	27.834	.72	2.2524	1502.0
2400.	3.508	34.980	3.308	1.09	27.842	27.849	.66	2.3461	1504.4
2500.	3.406	34.974	3.198	.38	27.847	27.855	.60	2.3927	1505.7
2600.	3.310	34.966	3.094	.79	27.850	27.859	.52	2.4387	1506.9
2800.	3.122	34.955	2.889	1.59	27.859	27.868	.61	2.5305	1509.5
3000.	2.962	34.944	2.712	.37	27.865	27.876	.57	2.6208	1512.2
3200.	2.840	34.937	2.572	.06	27.871	27.883	.58	2.7109	1515.1
3400.	2.698	34.929	2.412	.60	27.877	27.890	.56	2.8003	1517.9
3600.	2.583	34.920	2.278	.76	27.881	27.895	.56	2.8888	1520.8
3800.	2.488	34.914	2.163	.49	27.884	27.899	.48	2.9771	1523.9
4000.	2.426	34.909	2.079	-.13	27.885	27.902	.42	3.0656	1527.0
4200.	2.372	34.904	2.005	.13	27.886	27.904	.39	3.1549	1530.2
4400.	2.346	34.900	1.955	-.28	27.885	27.904	.29	3.2450	1533.6
4600.	2.328	34.895	1.914	-.14	27.882	27.904	-.06	3.3368	1537.0
4800.	2.321	34.893	1.882	.21	27.881	27.905	.20	3.4305	1540.4
5000.	2.315	34.889	1.852	.26	27.878	27.904	.28	3.5262	1543.8
5200.	2.296	34.883	1.808	-.11	27.875	27.902	.25	3.6236	1547.2

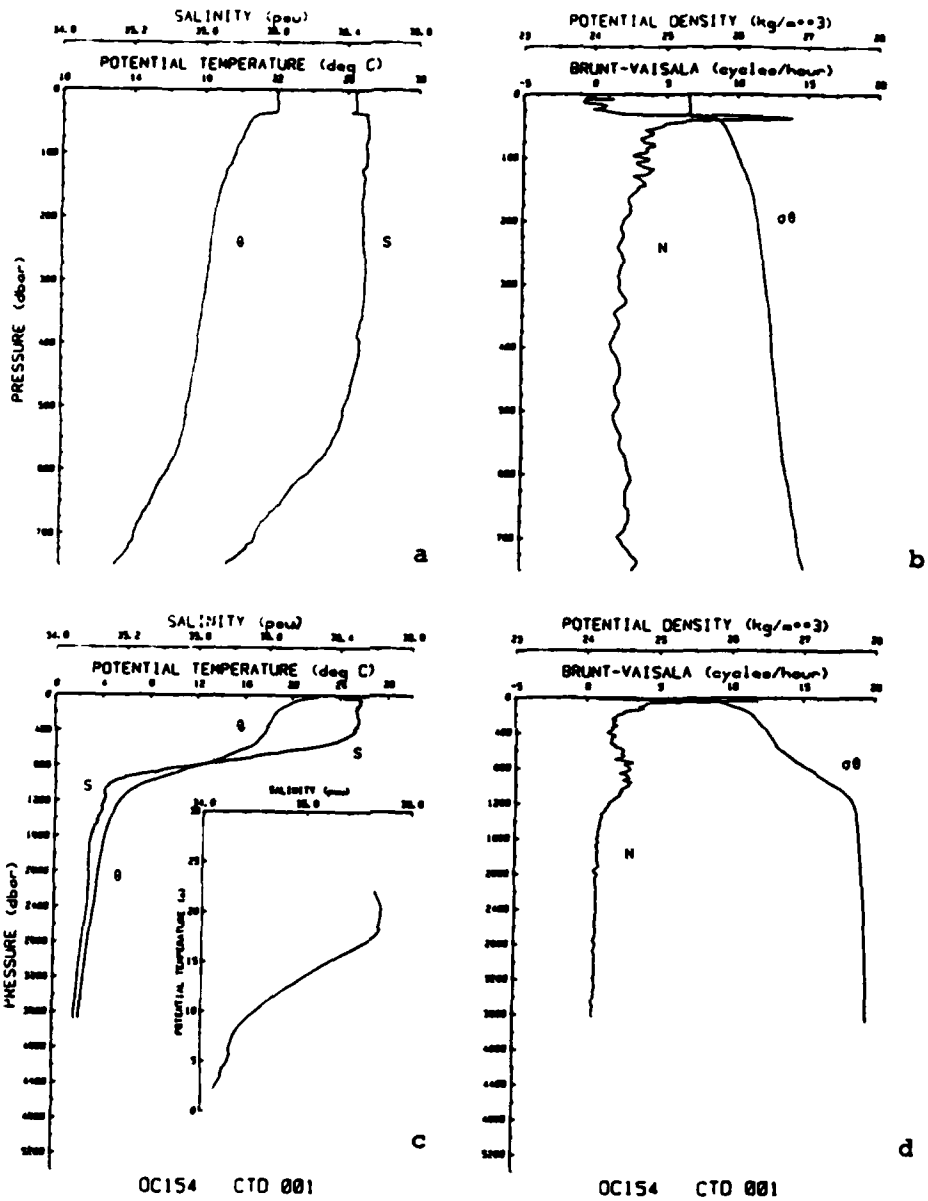

Figure 5. CTD station 1. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

Table 7: Listing of CTD data and derived quantities for station 6.

OC154 CTD 006 1984 141 1346Z 34 02.68N 69 58.92W corrD: 5363m

PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	DYNHGT dyn m	SSPEED m/s
2.	20.492	36.484	20.492	0.00	25.779	25.772	0.00	0.0000	1524.5
6.	20.484	36.498	20.484	1.14	25.792	25.785	2.18	.0082	1524.6
10.	20.484	36.498	20.483	-.60	25.792	25.786	.84	.0165	1524.6
16.	20.475	36.499	20.473	2.77	25.795	25.789	1.27	.0305	1524.7
20.	20.463	36.497	20.460	11.05	25.797	25.791	3.13	.0387	1524.7
26.	20.374	36.494	20.370	3.86	25.818	25.813	2.19	.0525	1524.6
30.	20.346	36.491	20.341	14.02	25.824	25.818	1.73	.0611	1524.6
36.	20.313	36.485	20.307	9.10	25.828	25.823	1.55	.0750	1524.6
50.	20.264	36.480	20.255	11.27	25.838	25.833	3.44	.1054	1524.7
66.	19.946	36.481	19.934	1.35	25.923	25.919	4.16	.1393	1524.1
76.	19.534	36.487	19.521	29.90	26.036	26.033	5.25	.1597	1523.1
100.	18.977	36.488	18.959	31.19	26.182	26.180	3.37	.2061	1521.9
126.	18.765	36.480	18.743	15.69	26.230	26.229	2.41	.2543	1521.8
150.	18.621	36.475	18.595	4.82	26.263	26.263	1.82	.2982	1521.7
200.	18.559	36.474	18.524	.30	26.277	26.280	.97	.3890	1522.4
250.	18.491	36.488	18.447	4.15	26.305	26.310	2.34	.4798	1523.0
300.	18.279	36.504	18.227	11.83	26.371	26.378	2.44	.5690	1523.3
350.	17.905	36.489	17.845	4.26	26.453	26.461	2.03	.6554	1523.0
400.	17.674	36.466	17.605	9.40	26.492	26.503	1.87	.7396	1523.1
450.	17.320	36.416	17.244	4.95	26.541	26.553	1.61	.8227	1522.9

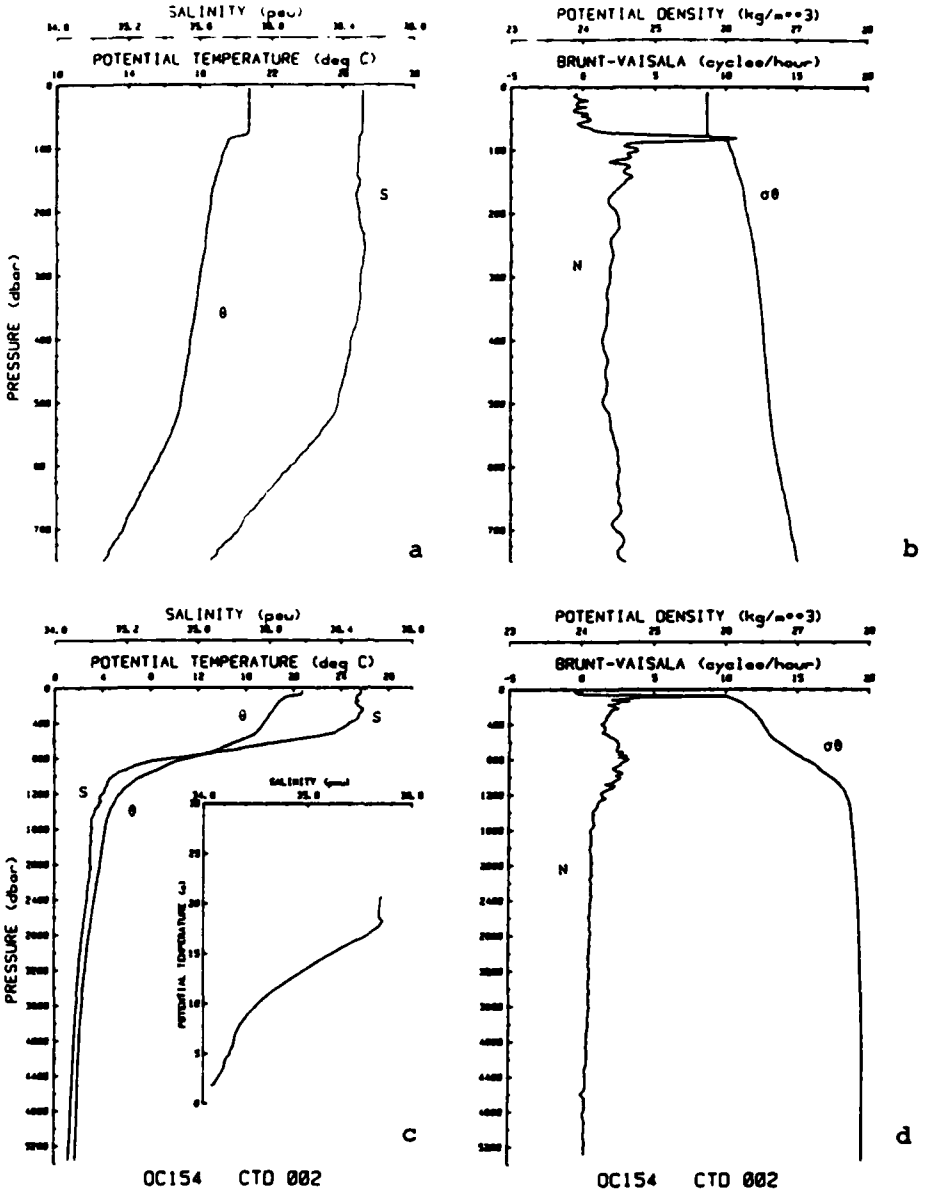

Figure 6. CTD station 2. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

Table 8: Listing of CTD data and derived quantities for station 7.

OC154	CTD 007	1984 141 2340Z		33 45.57N	69 59.19W		corrD: 5370m	
PRESS dbar	TEMP °C	SALIN psu	POTEMP °C	POTGRD m°C/db	SIGMA-t kg/m**3	POTDEN kg/m**3	BR-V cph	DYNHGT dyn m	SSPEED m/s
2.	20.968	36.490	20.968	0.00	25.655	25.648	0.00	0.0000	1525.8
6.	20.972	36.490	20.971	.09	25.654	25.647	.36	.0090	1525.9
10.	20.973	36.491	20.971	-.36	25.654	25.648	.46	.0188	1525.9
16.	20.974	36.492	20.971	2.50	25.654	25.648	.38	.0325	1526.0
20.	20.973	36.491	20.969	1.67	25.654	25.648	-.24	.0419	1526.1
26.	20.974	36.493	20.969	1.21	25.655	25.649	1.16	.0564	1526.2
30.	20.960	36.489	20.954	2.55	25.656	25.651	.98	.0658	1526.2
36.	20.947	36.488	20.941	3.54	25.659	25.653	1.74	.0799	1526.3
50.	20.805	36.488	20.796	10.24	25.698	25.693	2.97	.1126	1526.2
66.	19.998	36.507	19.986	5.85	25.929	25.926	3.75	.1481	1524.2
76.	19.766	36.506	19.752	11.09	25.990	25.987	4.05	.1687	1523.8
100.	19.372	36.465	19.354	15.23	26.062	26.060	2.88	.2170	1523.0
126.	19.283	36.501	19.260	18.56	26.112	26.111	3.18	.2678	1523.2
150.	19.029	36.492	19.002	8.38	26.171	26.172	3.11	.3145	1522.9
200.	18.628	36.489	18.593	1.34	26.271	26.273	2.49	.4061	1522.6
250.	18.357	36.511	18.313	14.61	26.356	26.361	2.12	.4956	1522.7
300.	18.060	36.504	18.008	6.81	26.426	26.432	1.74	.5820	1522.6
350.	17.904	36.499	17.844	1.02	26.460	26.469	1.29	.6664	1523.0
400.	17.645	36.465	17.577	2.00	26.498	26.509	1.48	.7507	1523.0
450.	17.356	36.427	17.279	5.35	26.540	26.552	1.71	.8345	1523.0
500.	17.011	36.374	16.927	8.85	26.583	26.597	1.81	.9161	1522.7
550.	16.352	36.251	16.262	23.49	26.645	26.659	2.35	.9960	1521.4
600.	15.644	36.128	15.549	13.16	26.714	26.729	2.16	1.0739	1519.9
650.	14.736	35.973	14.637	19.67	26.797	26.812	2.33	1.1474	1517.7
700.	13.980	35.861	13.876	15.25	26.874	26.888	2.16	1.2182	1516.0
750.	13.014	35.703	12.909	24.63	26.952	26.966	2.68	1.2852	1513.5
800.	12.047	35.577	11.940	4.95	27.046	27.058	2.22	1.3488	1510.9
900.	9.282	35.222	9.178	49.18	27.266	27.273	3.19	1.4605	1502.4
1000.	7.286	35.112	7.185	16.54	27.487	27.490	2.59	1.5481	1496.4
1100.	6.133	35.086	6.030	20.88	27.624	27.626	2.07	1.6173	1493.5
1200.	5.477	35.064	5.370	1.94	27.690	27.691	1.29	1.6769	1492.5
1300.	5.106	35.053	4.993	20.47	27.726	27.728	1.36	1.7318	1492.7
1400.	4.832	35.044	4.712	1.56	27.751	27.753	.85	1.7838	1493.2
1500.	4.601	35.027	4.474	2.80	27.764	27.766	.83	1.8349	1493.9
1600.	4.345	35.006	4.211	7.15	27.775	27.778	.80	1.8849	1494.5
1800.	4.103	35.000	3.954	2.62	27.797	27.800	.78	1.9829	1496.8
2000.	3.907	34.998	3.741	.32	27.816	27.821	.65	2.0792	1499.4
2200.	3.724	34.994	3.541	1.67	27.831	27.838	.70	2.1740	1502.0
2400.	3.525	34.984	3.325	.25	27.843	27.851	.61	2.2675	1504.5
2500.	3.430	34.978	3.222	.23	27.848	27.856	.59	2.3139	1505.8
2600.	3.333	34.972	3.117	.49	27.853	27.861	.59	2.3600	1507.0
2800.	3.152	34.960	2.919	1.04	27.860	27.870	.64	2.4517	1509.7
3000.	2.985	34.949	2.735	1.01	27.867	27.878	.64	2.5421	1512.3
3200.	2.816	34.940	2.549	.33	27.876	27.887	.60	2.6318	1515.0
3400.	2.673	34.931	2.387	.57	27.881	27.894	.54	2.7202	1517.8
3600.	2.552	34.922	2.247	.77	27.885	27.899	.56	2.8078	1520.7
3800.	2.460	34.916	2.136	.47	27.888	27.903	.45	2.8947	1523.7
4000.	2.402	34.911	2.057	.11	27.889	27.905	.41	2.9823	1526.9
4200.	2.362	34.907	1.995	.12	27.889	27.907	.34	3.0707	1530.2
4400.	2.338	34.903	1.948	.28	27.888	27.908	.30	3.1601	1533.5
4600.	2.322	34.899	1.908	.16	27.885	27.907	.18	3.2514	1536.9
4800.	2.316	34.895	1.878	-.07	27.883	27.907	.25	3.3445	1540.4
5000.	2.311	34.892	1.848	.17	27.881	27.907	.25	3.4395	1543.8
5200.	2.297	34.887	1.809	.30	27.878	27.905	0.00	3.5364	1547.2

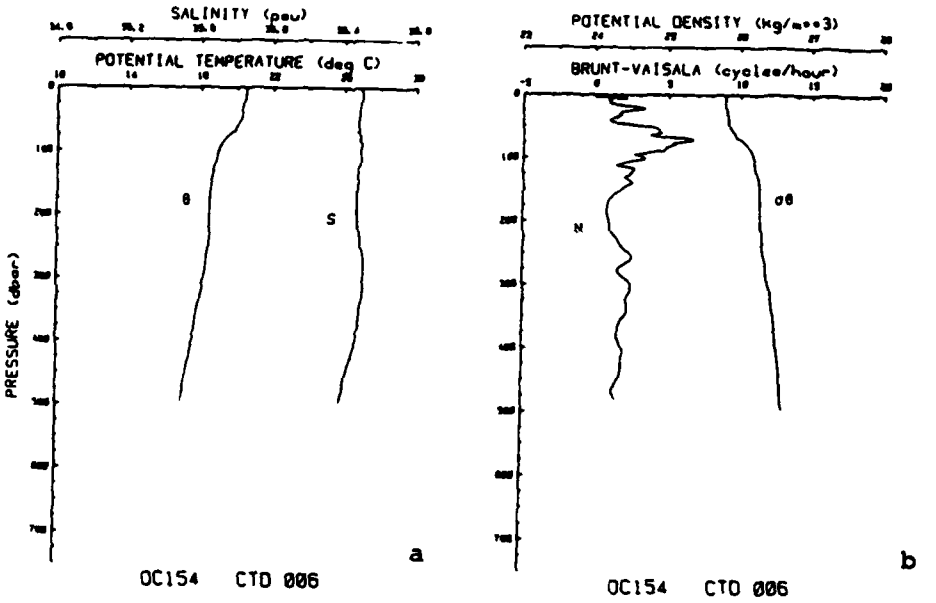

Figure 7. CTD station 6. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 500 m (a and b respectively).

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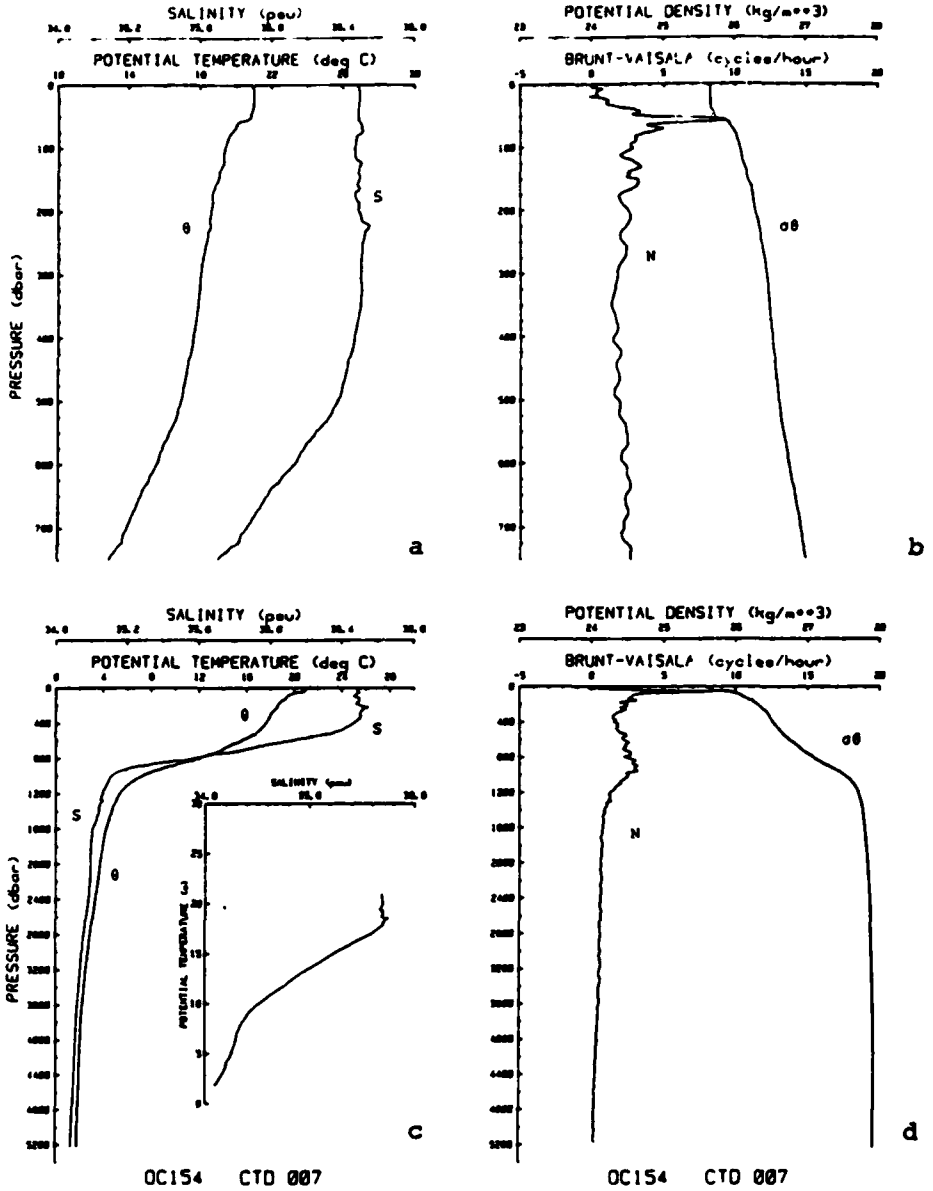

Figure 8. CTD station 7. Profiles of potential temperature (θ) and salinity (S), and Brunt-Väisälä frequency (N) and potential density (σ_θ) for the upper 750 m (a and b respectively) and for the entire cast (c and d respectively). θ-S diagram included in c.

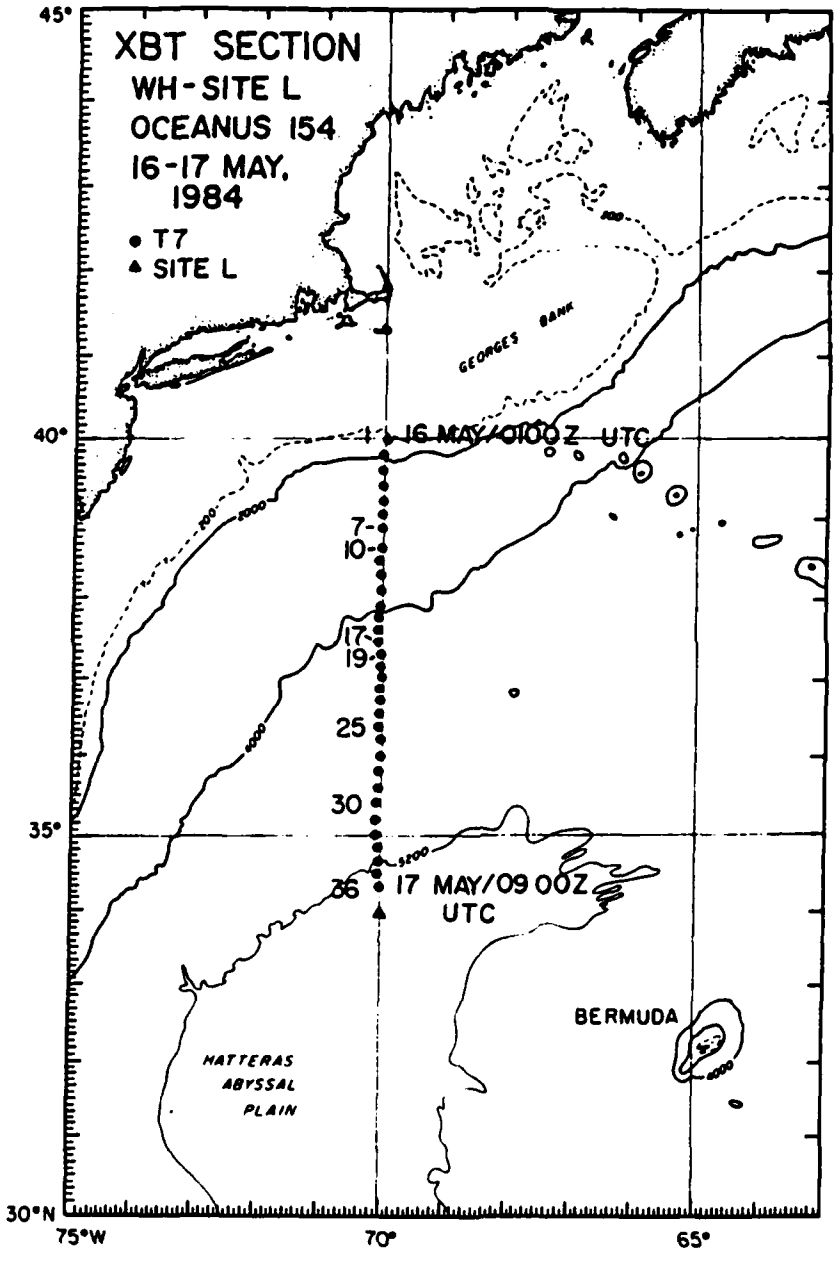

Figure 9. Chart showing the location of individual XBTs taken during the transit south to the LOTUS area, along 70°W.

B. XBT Data

Expendable bathythermograph data were collected approximately hourly (approximately every 20 km) along 70°W between 39°N and 34°N during the trip to the LOTUS area. The depths of the whole degree isotherms were transcribed from the strip chart records and plotted. Figure 9 is a chart showing the location of individual XBTs taken during the trip south. Figure 10 shows the XBT section from the southbound trip.

While in the LOTUS area, three detailed XBT sections were made, as a means of determining the extent of small scale horizontal variability in the upper ocean near the LOTUS site. XBTs were launched every 10 minutes (approximately every 4 km) along 70°W from 33°30'N to 34°30'N; along 34°N from 70°30'W to 69°30'W; and finally, along the line from 34°N, 69°30'W to 34°30'N, 70°W. The third section was made in order to recross a feature observed near the end of the northbound transit. Figure 11 shows the locations of the individual XBTs taken for the three detailed sections. The northbound section is shown in Figure 12, the eastbound section in Figure 13, and the northwesterly transit in Figure 14.

Vertical exaggeration of the XBT sections is 1:463. Figure 15 is an overplot of all the XBTs made in the LOTUS area during OCEANUS cruise 154. This presentation shows the range of temperatures observed due to the combined effects of the temporal and spatial variations.

A Bathysystems digital logger stores the XBT casts at 1/10 second intervals (approximately every 60 cm) for later analysis. Using a Sea Data 12A reader with an ARI (asynchronous interface) to an HP85A, we transcribe, edit, annotate, smooth, and store the data in 2 dbar intervals on flexible discs.

All LOTUS XBT traces are supplied to the National Oceanographic Data Center for general access and usage.

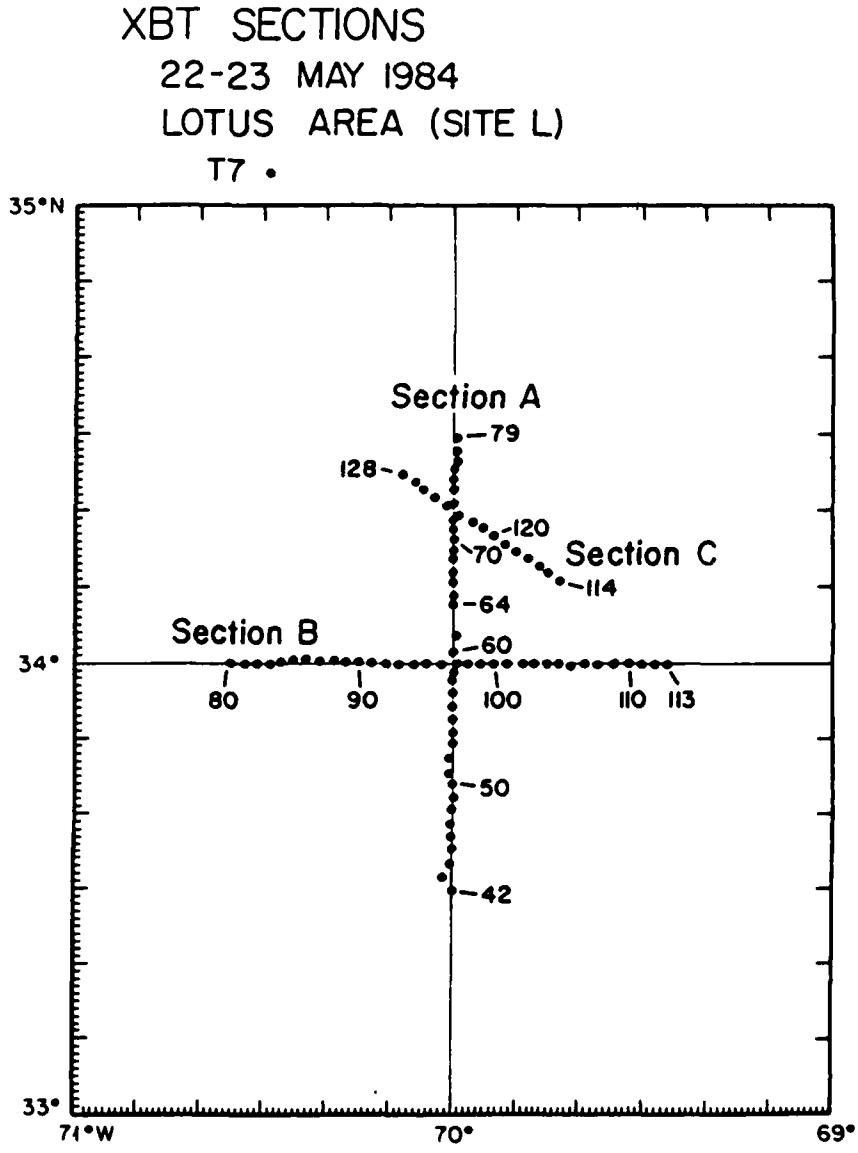

Figure 11. Chart showing the locations of individual XBTs taken during the three detailed sections made in the LOTUS area on OCEANUS 154.

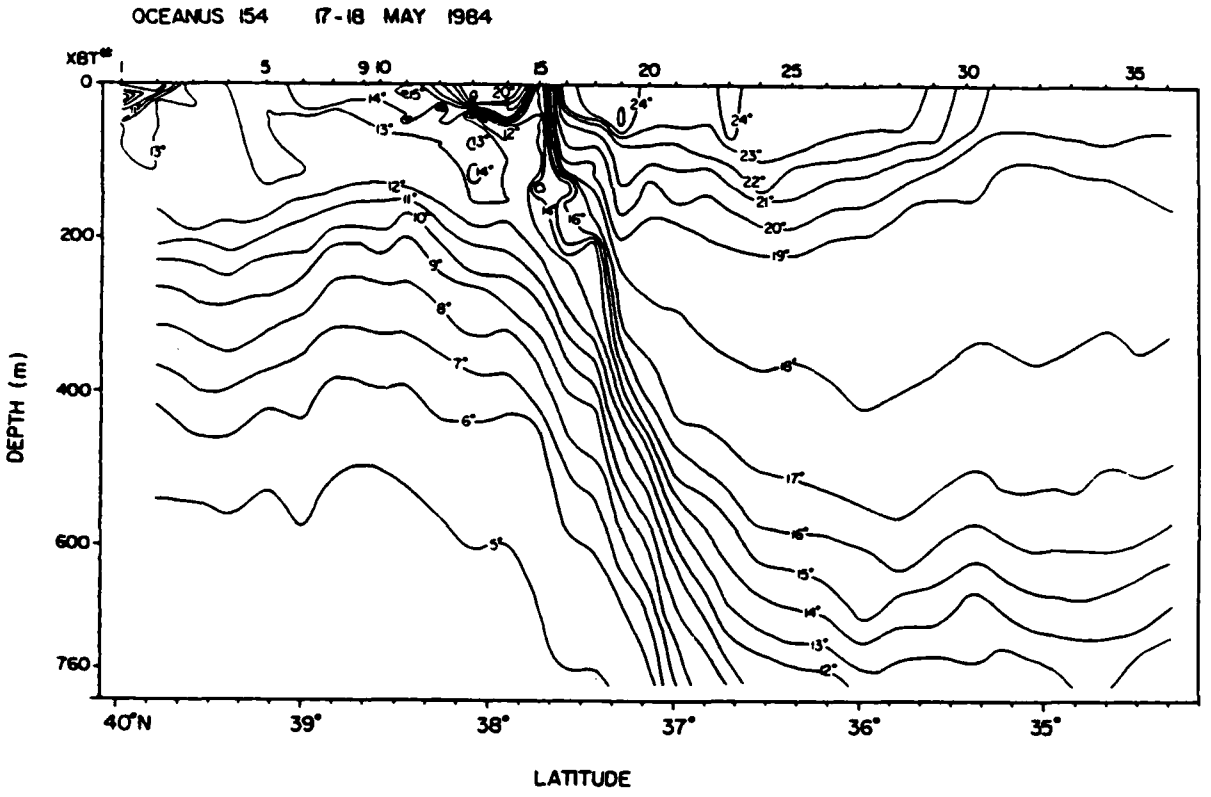

Figure 10. XBT section from the southbound transit along 70°W between 39°N and 34°N.

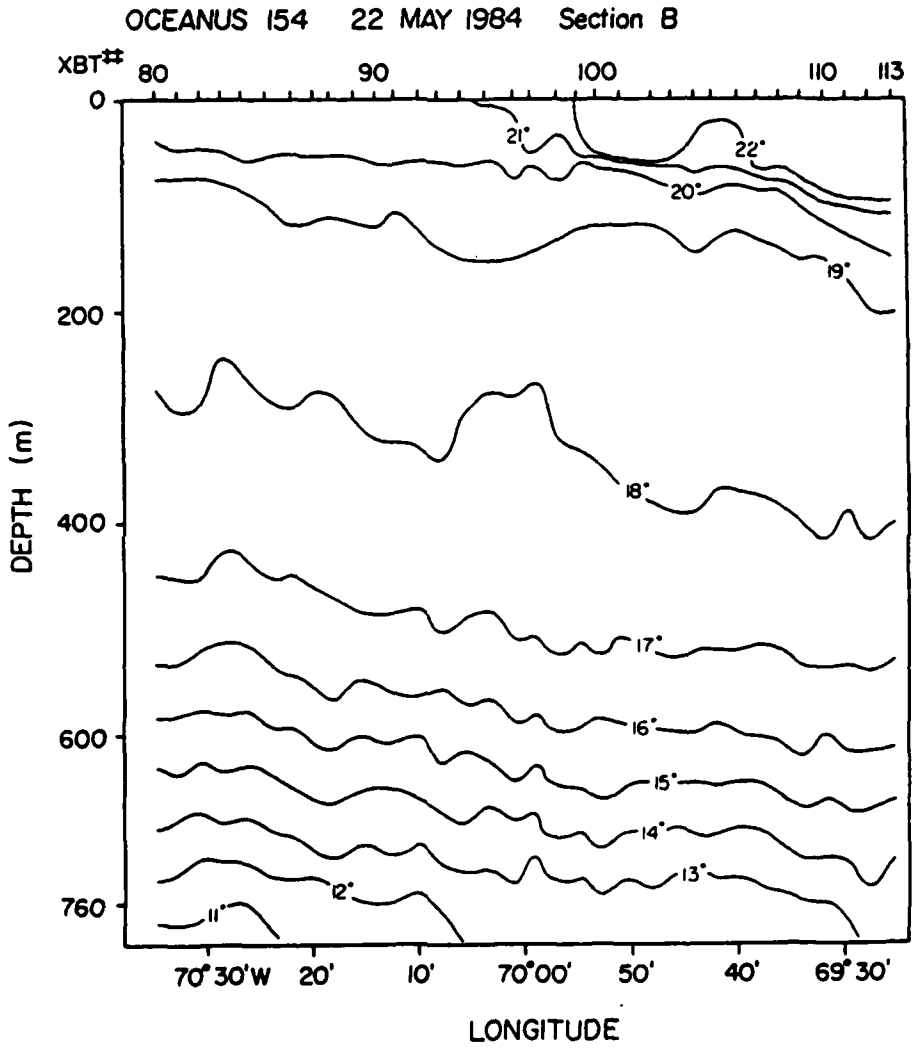

Figure 13. Detailed XBT section (numbers 80-113) from the eastbound survey along 34°N.

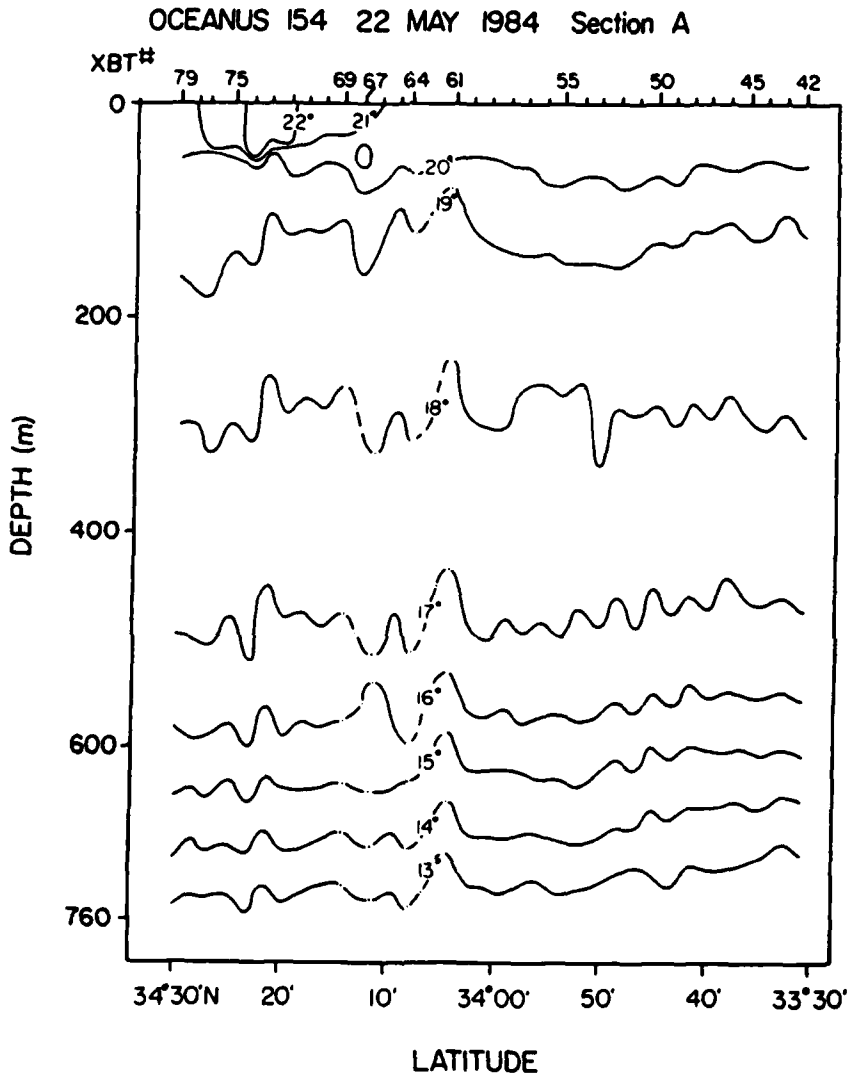

Figure 12. Detailed XBT section (numbers 42-79) from the northbound survey in the LOTUS area, along 70°W.

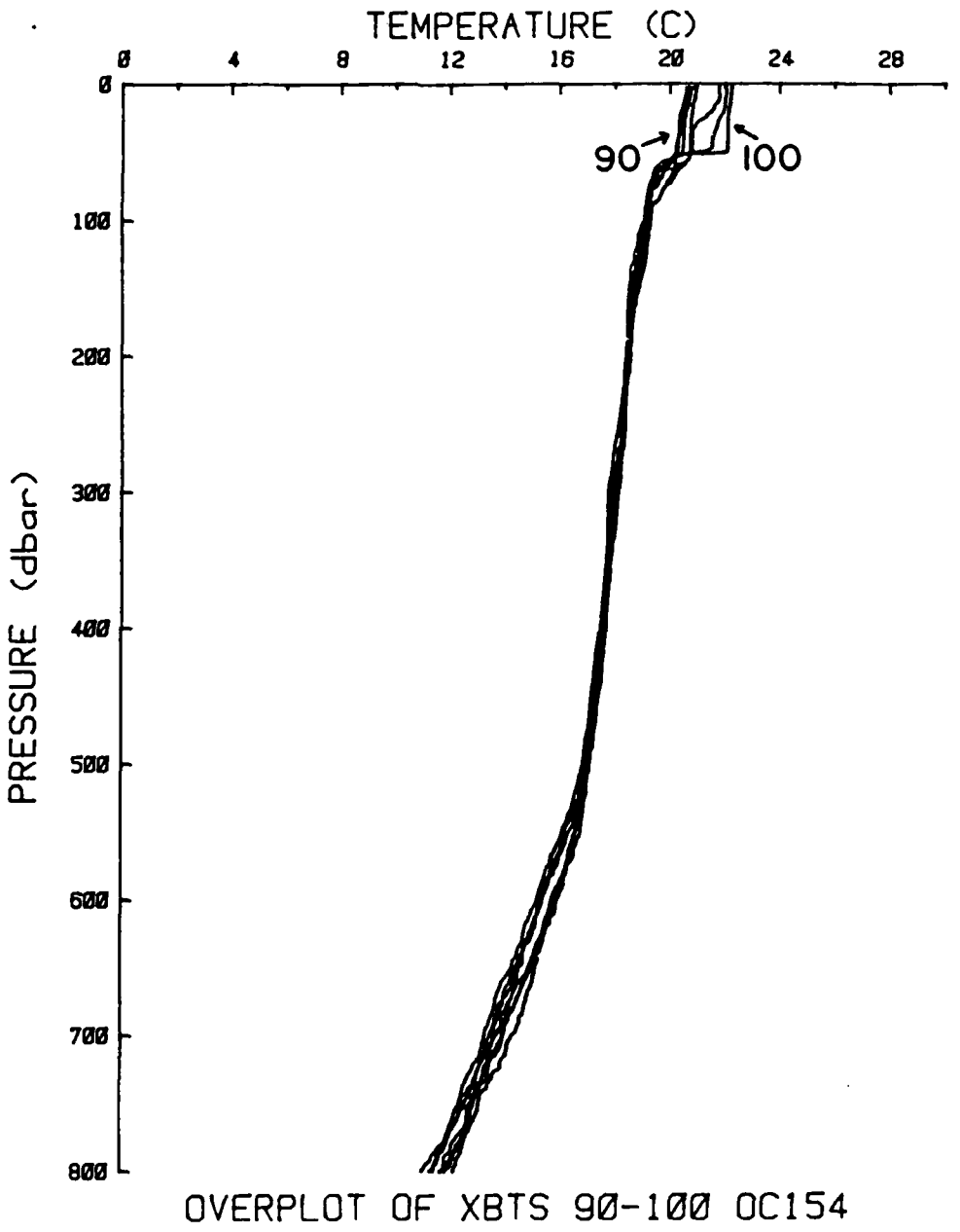

Figure 15. An overplot of XBTs (Nos. 90-100) taken in the LOTUS area during OCEANUS 154.

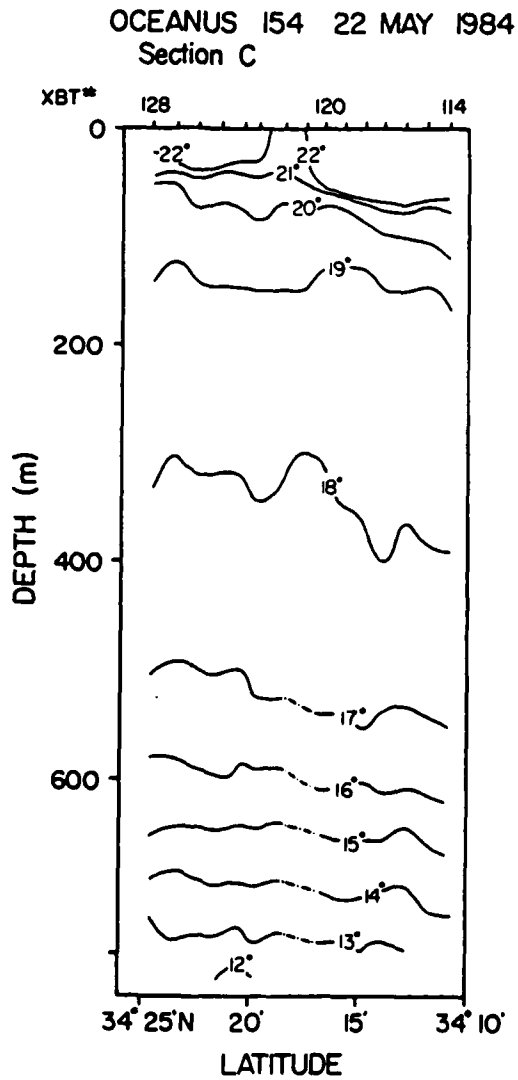

Figure 14. Detailed XBT section (numbers 114-128) from 34°N, 69°30'W to 34°30'N, 70°W.

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1330Z : Balls on surface.

1437Z : Top float grapnelled.

1631Z : Release aboard; securing gear before moving.

1730Z : Move to 789 (East Intermediate).

1920Z : Commence acoustic survey of 789.

2133Z : 789 released.

2138Z : Balls on surface.

2240Z : Commence hauling gear.

19 May - Day 140

0033Z : Release aboard; moving glass balls to 01 deck.

0130Z : Dumping wire to clear Pengo.

0319Z : CTD in water; Station 1 near 789 position.

0525Z : CTD aboard; pretripped at 1680 m off bottom.

0536Z : Move to 788 position.

0748Z : CTD Station 2, Northwest of LOTUS-6.

1033Z : CTD secured on deck.

1111Z : Commence acoustic survey of PCM.

1229Z : CTD Station 3, shallow 250 m dip near PCM.

1244Z : PCM released.

1245Z : Spheres on surface.

1300Z : Commence recovery of PCM.

1530Z : PCM recovery complete.

1625Z : On station to commence acoustic survey of 788 and 792.

1726Z : Released 788.

1727Z : Sphere on surface.

APPENDIX I

CHRONOLOGICAL SUMMARY

OCEANUS 154

16-23 May 1984

16 May - Day 137 (All times in UTC: Local is EDT = UTC-4)

1320Z	:	Leaving dock in Woods Hole.
1430Z	:	Science meeting in library.
2228Z	:	In between two USGS guard buoys, checking set and drift.
2303Z	:	Commence setting USGS mooring.
2346Z	:	Anchor over.
2353Z	:	Commence steaming for Site L.

17 May - Day 138

0100Z	:	First XBT on southbound section.
0901Z	:	Start half-hourly series of photos with mast camera.
1131Z	:	Changed NAV85 ASF's to 2.25, 2.29, from Woods Hole values.
1400Z	:	Sign reading "1400Z Day 138" placed under mast camera.
1518Z	:	Cloud cover 80% from 1200Z on, not dark but not bright. Wind from 330-350T at 20-30 knots. Sea State 4 with white caps 1330-1600Z, Sea State 3 with fewer white caps 1200-1330Z.

18 May - Day 139

0000Z	:	Last photo from mast in half-hourly series.
0900Z	:	XBT No. 36; last in southbound section.
1040Z	:	Close by LOTUS-6 buoy; no signs of Waverider buoy, considerable growth on bottom of discus.
1200Z	:	Commence acoustic survey of 790 (South Intermediate).
1325Z	:	790 released.

21 May - Day 142

0242Z : Station 7 completed.

0308Z : CTD secured in lab. Steam south to 33°30'N to begin XBT pattern.

0500Z : Begin 10-minute XBT survey northward from 33°30'N to 34°30' along 70°W; XBT No. 42.

1040Z : Last XBT on 70°W 10-minute section; No. 79.

1045Z : Steam to 34°N, 70°36'W for eastward XBT section.

1500Z : Begin E-W XBT section along 34°N; No. 80.

2030Z : Last XBT on 34°N 10-minute section; No. 113.

2037Z : Move NW through 34°20', 70°W.

2230Z : Begin 10-minute XBT section on crossing leg; No. 114.

22 May - Day 143

0050Z : Last XBT on 10-minute NW leg; No. 128.

0058Z : Set course for Site D; last work in LOTUS Land.

1450Z : Lots of lines of Sargassum visible; took mast photos.

1608Z : Sargassum lines gone; was in region between 36°49' and 37°01'N, along 70°07'W.

1745Z : Tests of Radar camera.

23 May - Day 144

0245Z : At Site D; working release on 791 (Engineering Mooring).

0304Z : Test new release on wire.

0407Z : Release 791.

[Heavy fog. No visible light or audible radio on mooring top. Searched for top, then bottom, by moving slowly and using searchlights. Weather and sea very calm.]

0502Z : Bottom of mooring spotted.

1735: : Sphere grapnelled/hooked.

1740Z : Sphere aboard and secured.

2039Z : Releases aboard.

2050Z : 788 recovery complete; gear secured.

2133Z : Relative humidity measurement at LOTUS-6.

2152Z : Commence CTD Station 4 to 500 m near LOTUS-6.

2227Z : Station complete; gear secured. Move East to 34°N, 69°W for CTD station, with hourly XBT's along the way.

2300Z : Commence XBT section; XBT No. 37.

20 May - Day 141

0300Z : Last XBT on section; No. 41.

0316Z : Commence CTD Station 5 at 34°N, 69°W.

0555Z : Station 5 completed. Move to LOTUS position.

0700Z (approx) Read CTD tape; turn-off system not working due to seawater leak in top connector. Stations 3, 4, 5 probably no good.

1325Z : Freighter "Consolidated Venture" near LOTUS-6; no response on radio.

1346Z : Commence CTD Station 6 to 500 m near LOTUS-6; repeat of Station 4.

1412Z : Station 6 completed.

1420Z : LOTUS-6 (mooring 792) released.

1508Z : Bottom ball cluster on surface.

1523Z : Commence hauling 792 bottom end first.

2020Z : Recovery of 792 complete.

2142Z : Deck secure. Move to position of 790 (South Intermediate).

2332 : Commence CTD Station 7 at 790 position.

0510Z	:	Bottom cluster on board.
0750Z	:	Finished hauling mooring.
0800Z	:	Move to start position to reset mooring.
0835Z	:	Commence deployment of 808 (engineering).
1437Z	:	Anchor over.
1455Z	:	Anchor on bottom.
1505Z	:	Underway for Pierre Biscaye's guard buoy south of Block Island.
1800Z	:	Alongside guard buoy; replace light.
1806Z	:	Steam for Woods Hole.
2320Z	:	At dock, Woods Hole.

End of OCEANUS 154.
End of LOTUS field work.

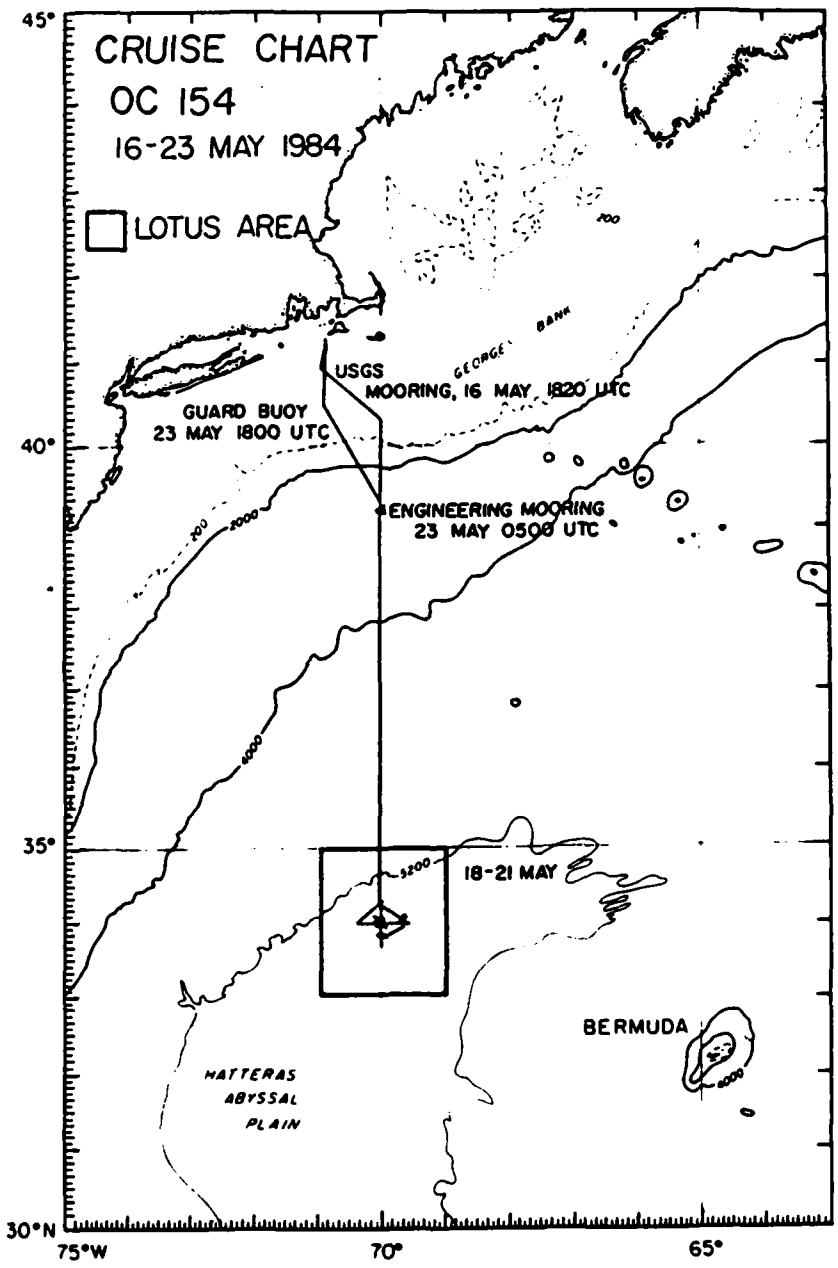

Figure A-1. Cruise track of OCEANUS cruise number 154.

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16. Abstract (Limit: 200 words)

OCEANUS cruise 154 (16-23 May 1984) was the final cruise in the two year field program of the Long Term Upper Ocean Study (LOTUS). The work occurred primarily in the LOTUS area (34°N, 70°W), where the entire moored array was recovered. The moorings were the following: the LOTUS-6 surface mooring (No. 792), a subsurface mooring (No. 788), two intermediate moorings (Nos. 789, 790), and a C.S. Draper Labs profiling current meter (PCM) mooring.

Also on OCEANUS 154, a mooring was deployed for the U.S. Geological Survey at approximately 40°10'N, 69°58'W. On the return trip, an engineering test mooring was recovered at approximately 39°11'N, 70°01'W, some elements removed for testing, and then redeployed in the same location.

This report presents the hydrographic data collected on OCEANUS 154, as well as providing details of the work that was accomplished.

17. Document Analysis a. Descriptors

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2. Moorings
3. Sargasso Sea
4. Buoys

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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